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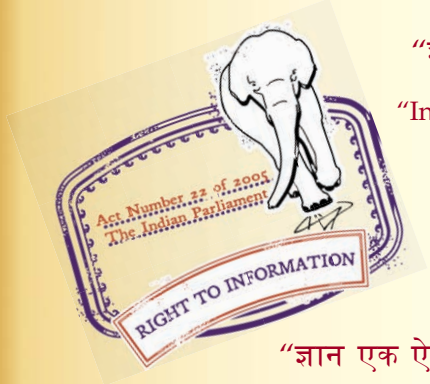

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Indian Standard

SPECIFICATION FOR IMPREGNATING OILS AND COMPOUNDS FOR PAPER INSULATED CABLES UP TO 33 kV

UDC 621·315·221·3:621·315·614·6

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4

November 1986

Indian Standard

SPECIFICATION FOR IMPREGNATING OILS AND COMPOUNDS FOR PAPER INSULATED CABLES UP TO 33 kV

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Indian Standard

SPECIFICATION FOR IMPREGNATING OILS AND COMPOUNDS FOR PAPER INSULATED CABLES UP TO 33 kV

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 24 January 1986, after the draft finalized by the Liquid and Gaseous Dielectrics Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is intended to cover requirements of impregnating oils and compound for paper insulated cables up to 33 kV.

0.3 The requirements of paper insulated lead-sheathed cables (PILC) for electricity supply are covered in IS : 692-1973*. In the manufacture of such cables insulating oils and compounds are used as impregnants. These products are of the following two types:

a) draining type oils, and

b) non-draining compounds.

This standard is intended to cover the requirements of these impregnants.

0.4 The requirements of the impregnants used in PILC cables have been based on the characteristics of the products used widely in the cable industry. These petroleum/petrochemical based oils and compounds are intended to impregnate the paper insulation of the cables and assist in filling the voids and spaces between the various layers of insulation so that the finished cable complies with the requirements of IS : 692-1973*.

0.5 In the preparation of this standard, assistance has been derived from ASTM D 1903- 1983 'Standard test method of coefficient of thermal expansion of electrical insulating liquids of petroleum origin and askarels', issued by American Society for Testing and Material (USA).

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of test or analysis, shall be rounded off in accordance

*Specification for paper insulated lead sheathed cables for electricity supply (*second revision*).

with IS : 2-1960*. The number of significant places retained in the rounded off values should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies requirements and methods of tests for impregnating oils and compounds used for manufacture of PILC cables up to 33 kV.

1.2 The impregnants covered in this standard are of the following two types:

a) draining type oils, and

b) non-draining compounds.

1.3 This standard does not cover the requirements of oils used as coolants in hollow core cables.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Flash Point — The temperature at which the oil/compound gives off so much vapour that this vapour when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under the prescribed conditions of test.

2.2 Pour Point — The lowest temperature expressed as a multiple of 3°C at which the oil/compound is observed to flow when cooled and examined under prescribed conditions.

2.3 Drop Point — For the purpose of this standard, the drop shall be temperature at which compound passess through semi solid to a liquid state under the conditions of the test.

2.4 Neutralization Value (Total Acidity) — A measure of combined organic and inorganic acidity. It is observed in terms of number of milligrams of potassium hydroxide required to neutralize the total free acids in one gram of the oil/compound.

2.4.1 *Inorganic Acidity* — A measure of mineral acid present. It is expressed in terms of number of milligrams of potassium hydroxide

*Rules for rounding off numerical values (*revised*).

required to neutralize the inorganic (mineral) acid in one gram of the oil/compound.

2.4.2 *Organic Acidity* — A measure of organic acid present. It is expressed in terms of number of milligrams of potassium hydroxide required to neutralize the organic acid in one gram of the oil. It is obtained by deducting the inorganic acidity from the total acidity.

3. COMPOSITION

3.1 The draining type and non-draining type cable oils/compounds shall be either mineral oil based or synthetic hydrocarbon based.

3.2 The draining type cable oil shall be based on refined mineral petroleum oil and/or synthetic hydrocarbon or refined resins.

Additives to enhance the oxidation stability may be incorporated. Pour point depressant additives are not permitted.

3.3 The mass impregnating non-draining compound shall be based on refined mineral petroleum oil and/or synthetic hydrocarbon and waxes.

Additives to enhance the oxidation stability may also be included.

3.4 Both the types, should be free from extraneous contamination, such as moisture sediments, fibres, etc, which is deleterious to materials used in cable manufacture.

4. REQUIREMENTS

4.1 The requirements of the various grades of cable oils/compounds as indicated in **3.1** are listed in Table 1.

4.2 The requisite grade shall conform to the characteristics indicated in the relevant column when tested in accordance with the method stipulated in column 7 of Table 1.

5. PACKING

5.1 The oil/compound shall be packed in suitable steel drums effectively sealed to exclude moisture and prevent the ingress of other contaminants. The size and capacity of the drum shall be as agreed to between the purchaser and the supplier.

5.2 The draining type oils may also be supplied in road/rail tankers, fitted with adequate safety equipment to avoid contamination.

TABLE 1 SCHEDULE OF CHARACTERISTICS

(*Clause* 4.1)

Sl No.	Characteristics	Requirements of Draining Type		Requirements of Non-Draining Type		Method of Test
		Mineral Oil Based	Synthetic Hydrocarbon Based	Mineral Oil Based	Synthetic Hydrocarbon Based	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	a) Kinetic viscosity, mm^2/s at					
	1) 100°C	30-70 Cst	190-800 Cst	—	—	IS : 1448 [P : 25]-1960*
	2) 120°C	—	—	20-40 Cst	60-90 Cst	
	3) 140°C	—	—	—	30-50 Cst	
	b) Viscosity index	—	115	—	—	
ii)	Relative density at 15·6°C	0·95	0·92	0·95	0·92	IS : 1448 [P : 32]-1960†
iii)	Flash point, *Min*	180°C	180°C	180°C	180°C	IS : 1448 [P : 21]-1970‡
iv)	Pour point	0	0	—	—	IS : 1448 [P : 10]-1970§
v)	Dropping point, °C *Min*	—	—	95	95	IS : 1448 [P : 52]-1971‖
vi)	Neutralisation value:					
	a) Total acidity, *Max*	Report	0·05	Report	0·05	IS : 1448 [P : 2]-1960¶ Method B
	b) Inorganic acidity	Nil	Nil	Nil	Nil	Method C
vii)	Cone penetration at 25°C, *Min*	—	—	95	95	IS : 1448 [P : 92]-1960**
viii)	Synerisis test	No separation of the constituents	No separation of the constituents	No separation of the constituents	No separation of the constituents	Appendix D
ix)	Water content, ppm, *Max*	50	50	(Under consideration)	Under consideration)	IS : 2362-1963†† (Method of test for non-draining compounds are under consideration)
x)	Coefficient of expansion, °C, *Max*	0·0007	00·007	do	do	Appendix C

xi) Specific resistance (resistivity) ohm-cm, *Min*					
a) Resistivity before ageing at 100°C	10×10^{12}	150×10^{12}	5×10^{12}	150×10^{12}	IS : 6103-1971‡‡ and Appendix A
b) Resistivity after ageing at 100°C	1×10^{12}	50×10^{12}	$0{\cdot}5\times10^{12}$	50×10^{12}	do
xii) Dielectric strength (breakdown value) kV, *Min* at 100°C	40	40	40	40	IS : 6792-1972§§
xiii) Absorption index, *Max*	—	—	18	18	Appendix B
xiv) Dielectric dissipation factor (Tan δ) (*Max*) at 100°C					
a) before ageing	0·003	0·000 5	0·005	0·001	IS : 6262-1971‖‖ and Appendix A
b) after ageing	0·02	0·002 5	0·02	0·005	

*Methods of test for petroleum and its products, P : 25 Determination of kinematic and dynamic viscosity (*first revision*).

†Methods of test for petroleum and its products, P : 32 Density and relative density (*first revision*).

‡Methods of test for petroleum and its products, P : 21 Flash point (closed) by pensky-Martens apparatus (*first revision*).

§Methods of test for petroleum and its products, P : 10 Cloud point and pous-point (*first revision*).

‖Methods of test for petroleum and its products, P : 52 Drop point (*first revision*).

¶Methods of test for petroleum and its products, P : 2 Acidity (*first revision*).

**Methods of test for petroleum and its products, P : 92 Cone penetrations of petroleum.

††Determination of water by the Karl Fischer method (*first revision*).

‡‡Method of test for specific resistances (resistivity) of electrical insulating liquids.

§§Methods for determination of electric strength of insulating oils.

‖‖Methods of tests for power factor and dielectric constant of electrical insulation liquids.

6. SAMPLING

6.1 For carrying out the tests referred to in Table 1, the representative sample shall be drawn in accordance with the applicable procedure for heavy lubricating oils and petroleum jelly for draining and non-draining compounds respectively as indicated in IS : 1447-1966*.

7. MARKING

7.1 Each container shall be indelibly marked with the following:

a) Manufacturer's name,

b) Type of compound,

c) Brand name of the product or trade-mark or both,

d) Quantity in litres/kg, and

e) Identification or suitable code to enable the date and lot of manufacture to be traced back to the factory records.

7.1.1 Each barrel or drum may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

8. QUALIFICATION APPROVAL

8.1 For the purpose of this standard the concept of approved sample will hold. The supplier shall therefore submit a sample of the relevant grade to the purchaser and obtain his approval regarding its suitability and conformity with this standard. The characteristics of this sample shall be recorded.

8.2 Each supply of the oil/compound shall be accompanied with a test certificate giving information of the test results according to Table 1.

8.3 The supplier will bind himself to make all subsequent supplies in accordance with the characteristics recorded for the approved sample subject to tolerances on each characteristic as agreed to between the purchaser and the supplier.

*Methods of sampling of petroleum and its products.

APPENDIX A

[*Table* 1, *Items* (xi) *and* (xiv)]

AGEING TEST

A-1. PROCEDURE

A-1.1 450 grams of oil/compound weighed in swat 600-ml beaker shall be maintained at a temperature of 115° ± 1°C for a period of 96 hours in the presence of a copper catalyst prepared in accordance with **A-1.2.**

A-1.2 A strip of mechanically polished pure soft electrolytic copper sheet, approximately 13 mm in width and 75 mm in length. The strip shall be cleaned and polished on both sides, by means of a pad of cotton wool and 150 grade silicone carbide (carborundum is suitable) powder, and rubbed with successive pads of cotton wool until such time as a fresh pad remains unsoiled after having been rubbed on the foil. It shall finally be washed with a volatile, sulphur-free solvent, such as diethyle ether and allowed to dry. Subsequent, handling of the strip shall be with clean metal forceps.

A-1.3 The test shall be carried out in a thermostatically controlled bath in an atmosphere free of draughts. The beaker containing the sample shall be open to the atmosphere and immersed so that the levels of the surface of the sample and the liquid in the bath are the same.

APPENDIX B

[*Table* 1, *Item* (xiii)]

ABSORPTION INDEX

B-1. GENERAL

B-1.1 A sample of the wax-like compound is filled into a watch glass like aluminium dish. This is kept in intimate contact with cable insulating paper for a period of 16 hours at 85°C. The increase of the circumference of the container to the circumference of the oil stain on the paper is called the 'absorption index'.

B-2. APPARATUS

B-2.1 a) Concave aluminium dish;

b) 140 micrometer all wood cable insulating paper, apparent density 0·75 ± 0·01 tonne/m^2.
Porosity 140-160 Gurely seconds;

c) Suitable clamp device for holding the paper squares with the compound samples (*see* **B-3.3**);

d) Electrically heated oven operating at 85 ± 2°C with air circulation; and

e) A means of measuring the periphery of an area on a piece of paper (map reader or a length of nylon thread).

B-3. PROCEDURE

B-3.1 Fill the clean aluminium dish as completely as possible with the compound which has been heated to about 10°C above its melting point. Allow it to cool, then level the compound as accurately as possible to the surface of the dish, using a warmed stiff-bladed knife or spatula.

B-3.2 Cut a 150 mm square of the insulating paper and place the dish filled with compound face downward exactly in the middle of the paper.

Use only slight finger pressure to ensure contact of the compound to the paper.

B-3.3 Fix the paper square and sample rigidly in a horizontal plane and stand the assembly in the oven at 85°C with the air vents closed. A suitable clamping method is to use two perforated metal cylinders, about 110 mm in diameter, 15 mm tall, having small holes drilled through the metal wall to allow free circulation of air.

B-3.4 After 16 hours remove the sample(s) from the oven and allow to cool. Place the dish in such a way that the paper remains at the top. Carefully remove the clamps and measure the diameter of the outer mask in the paper in 8 positions and calculate the perimeter (Xcm). Deduct from this the circumference of the aluminium dish (Ycm). Similarly, measure and calculate the absorption index as $X-Y$.

APPENDIX C

[*Table* 1, *Item* (x)]

DETERMINATION OF COEFFICIENT OF EXPANSION OF ELECTRICAL INSULATING OILS AND COMPOUNDS

C-1. GENERAL

C-1.1 This method covers the determination of the coefficient of thermal expansion of electrical insulating liquids of petroleum origin, for use in PILC cables, as an insulating or cooling medium or both.

C-2. SIGNIFICANCE

C-2.1 A knowledge of the coefficient of expansion of a liquid is essential to compute the required size of a container to accommodate a volume of liquid over the full temperature range to which it will be subjected. It is also used to compute the volume of void space that would exist in an inelastic device filled with the liquid after the liquid has cooled to a lower temperature.

C-3. DEFINITION

C-3.1 Coefficient of Thermal Expansion of Liquid — The change in volume per unit volume per degree increase in temperature. It is commonly stated as the average coefficient over a given temperature range.

C-4. PROCEDURE

C-4.1 In the preparation of these tables for specific gravity values above 0·600, it has been assumed for purposes of standardization that all crude petroleum and petroleum products have uniform coefficient of expansion in the same temperature ranges. When the required accuracy of result falls within these assumptions, this value for coefficient of expansion may be used.

C-4.2 If closer approximation than that indicated in **4.1** is required, the coefficient of expansion may be calculated by determining observed specific gravities using IS : 1448 [P : 16]-1977*. Determine the specific gravities at any two temperature below 90°C and not less than 5°C not more than 14°C apart. The difference in the observed specific gravities at the two temperatures divided by the product of the specific gravity at the lower temperature and the difference in the two temperatures may be used at the average coefficient of expansion for the observed temperature range.

C-5. CALCULATION

C-5.1 Calculate the coefficient of thermal expansion as follows:

Coefficient of thermal expansion:

$$= (S - S_1)/S\,(T_1 - T)$$

where

S = specific gravity of lower temperature T,

S_1 = specific gravity at higher temperature T_1,

T = lower temperature, and

T_1 = higher temperature.

*Methods of test for petroleum and its products, P : 16 Density of crude petroleum and liquid petroleum products by hydrometer method (*second revision*).

APPENDIX D

[*Table* 1, *Item* (viii)]

SYNERISIS TEST

D-1. GENERAL

D-1.1 A sample of impregnating (oil or non-draining compound) is kept static at a temperature above the melting point for fixed period. During this interval, if the constituents of this sample separate unit as can be optically observed, it would indicate an unstable system. This phenomenon is called synerisis.

D-2. APPARATUS

D-2.1 a) 250 ml graduated cylinder,

b) Electrically heated oven operating at 120 ± 2°C with air circulation,

c) Abbes refractometer,

d) Viscometer,

e) Pipette, and

f) Battery or any suitable light arrangement.

D-3. PROCEDURE

D-3.1 a) For non-draining compound it is necessary to heat the oil to about 10°C above its melting point and then filling it in the cylinder.

b) The cylinder with the sample is kept in the oven at a temperature 120°C for 7 days.

c) After 7 days, if the sample is observed to be divided into 2 or more layers indicates, 'Synerisis' in the sample. A battery or any suitable device is to be used for visual observation of the sample. This can be further confirmed by taking the top and bottom layer samples from the cylinder and determining the viscosity at 60°C for heavy cable oil and at 120°C for non-draining compound.

Additionally, refractive index of the top and bottom layer sample can be determined.

If the viscosity and refractive index is found to be different for 2 layers taking into consideration the limits of experimental error, it indicates that the constituents have separated out from the oil sample leading to the presence of synerisis.

REPORT:

Report the results as follows:

Refractive Index	*Top Layer*	*Bottom Layer*
Viscosity in Cst		
at 60°C		
at 150°C		

Synerisis Test: Passes/Fails

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 $c/s(s^{-1})$
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2